DIRECTED ENERGY WEAPONS

and

ACTIVE PROTECTION SYSTEMS

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Report Documentation Page

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Abstract

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Number of Pages
15

1. Principle of operation

Geometric optics:-

Paraboloid mirror focuses point source

Pair of surfaces direct area or volume source

Not diffraction limited !

2. Single stage

Defining mirror chosen (typically spherical)

Defining rays chosen (collimated, focussed or whatever)

Defined mirror's shape is a solution to a differential equation

Further rays partially directed

Angular input aperture allows area or volume source

Out-of-plane rays

Reflective and/or refractive surfaces

3. Multiple stages in series

Stage multiplication $\propto$ 1 / angular input aperture squared

$\tan \beta_3 = - \tan(\theta_2 - \theta_1) \ \tan \ 0.75 \ (\theta_2 - \theta_1) \ \tan \ 0.5 \ (\theta_2 + \theta_1)$

θ_1	145	142.2	100.000
θ_2	160	140.0	100.034
β	23	8	0
$0.5 \ (\theta_2 + \theta_1) - \beta$	129.5	133.1	100.017
$2 \theta_2 - 2 \theta_1$	30	4.4	0.068
β_3	3.699	0.0678	8.57×10^{-5}
$\tan \beta_3$			1.49×10^{-6}

4. Beam adjustment and rotation

Moveable 3rd stage defined mirror

Axial movement focuses beam

Transverse movement corrects atmospheric distortion

40ms search to find target

High agility

Blackbody radiation - 1.5 MW$_e$ arc lamps (spatially but not temporally coherent)

Power increases as wavelength decreases (0.2 - 1.4 μm)

Wein's displacement law :- λ_m T = constant

Stefan - Boltzmann law :- P$_{tot}$ = σ T^4

Wide waveband - No Stimulated Raman Scattering

No lenses, lasing medium or inhomogeneities to distort beam

Power $\propto$ mirror size $\propto$ cooling

6. Dynamic kill on a continuous basis

Optimum range cusp

Effects of lower wavelengths:-

Smaller spots

Higher power

Poor reflectivity

Reduced dynamic kill threshold

More absorption and scattering

7. Typical applications

Application		Power
Combat aircraft	- 0.6m turret	$3.5MW_e$ / $1.4MW_{opt}$
	- 0.5m pod	$3.5MW_e$ / $1.4MW_{opt}$
	- 0.5m pod with APU &HPG	$15MW_e$ / $6MW_{opt}$
Transport aircraft	- 0.6m turret	$3.5MW_e$ / $1.4MW_{opt}$
Future Combat System	- 0.75m flush turret	$15MW_e$ / $6MW_{opt}$
Airborne DEW	- 3.6m turret	$200MW_e$ / $80MW_{opt}$
Space based DEW	- 2m diamond turning	$240MW_e$ / $100MW_{opt}$
	- 4.5m diamond turning	$1000MW_e$ / $400MW_{opt}$

8. Active protection

All types of platform

All types of target

Rate of fire exceeds all but LAA - typical 200ms engagement

Protection of accompanying forces:- APCs, dismounted infantry

Relation to countermeasures & jamming

9. Combat aircraft

BASIC   1600 lbs

3.5 MW_e iron rotor homopolar generator

Two 24in diameter DEW turrets

4 UV+ fire control sensor turrets

12 MWIR sensors

OPTIONAL

24in diameter pod for longer range DEWs

ALTERNATIVE POWER SUPPLY

136 kW APU + 11 MJ IED HPG

10. Number of Targets Engaged

1st DEW $n((R-r)/v+0.1)$

2nd DEW $n(R-r)/v$

n   pulses/sec   5 for missiles   3.3 for hittiles

R   metres   effective range

r   metres   minimum range

v   metres/sec   relative velocity

Turret

	1st DEW	2nd DEW
IRGMs head - on		
Clear at sea level	6	5
Median haze at sea level	2	2

Pod

	1st DEW	2nd DEW
Head - on		
Clear/Radar guided missiles	11	11
Median Haze/Beam-riding hittiles	3	2

11. All Types of Target

IRGMs

Active, semi-active and passive radar guided missiles

Beam-riding or command guidance hittiles

Aircraft

HAA

LAA (All shells or selected)

KE long-rod penetrators

12. Relation to Countermeasures

DEW as jammer at very long range

Counter to imaging IR seekers distinguishing flares

Vulnerability of launch operation in beam-riding system

No point in weight penalty for stealth

ARMs vulnerable to DEWs using comercial sources

Shoulder fired DEWs with chemical rounds

13. Radar Jamming

Invulnerable stand forward jamming platform

$3.5\ MW_e$ available

Barrage jamming over a wider waveband counters LPI

Room for high power jammers in same pod

"Moving" chaff by illumination

Escorting cruise missiles using DEWs and jammers